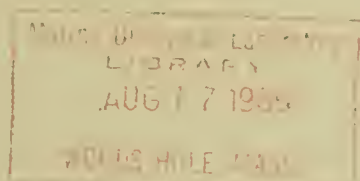


Biological Investigations of Purse Seine Fishery for Atlantic Menhaden

by Kenneth A. Henry



SPECIAL SCIENTIFIC REPORT-FISHERIES No. 519

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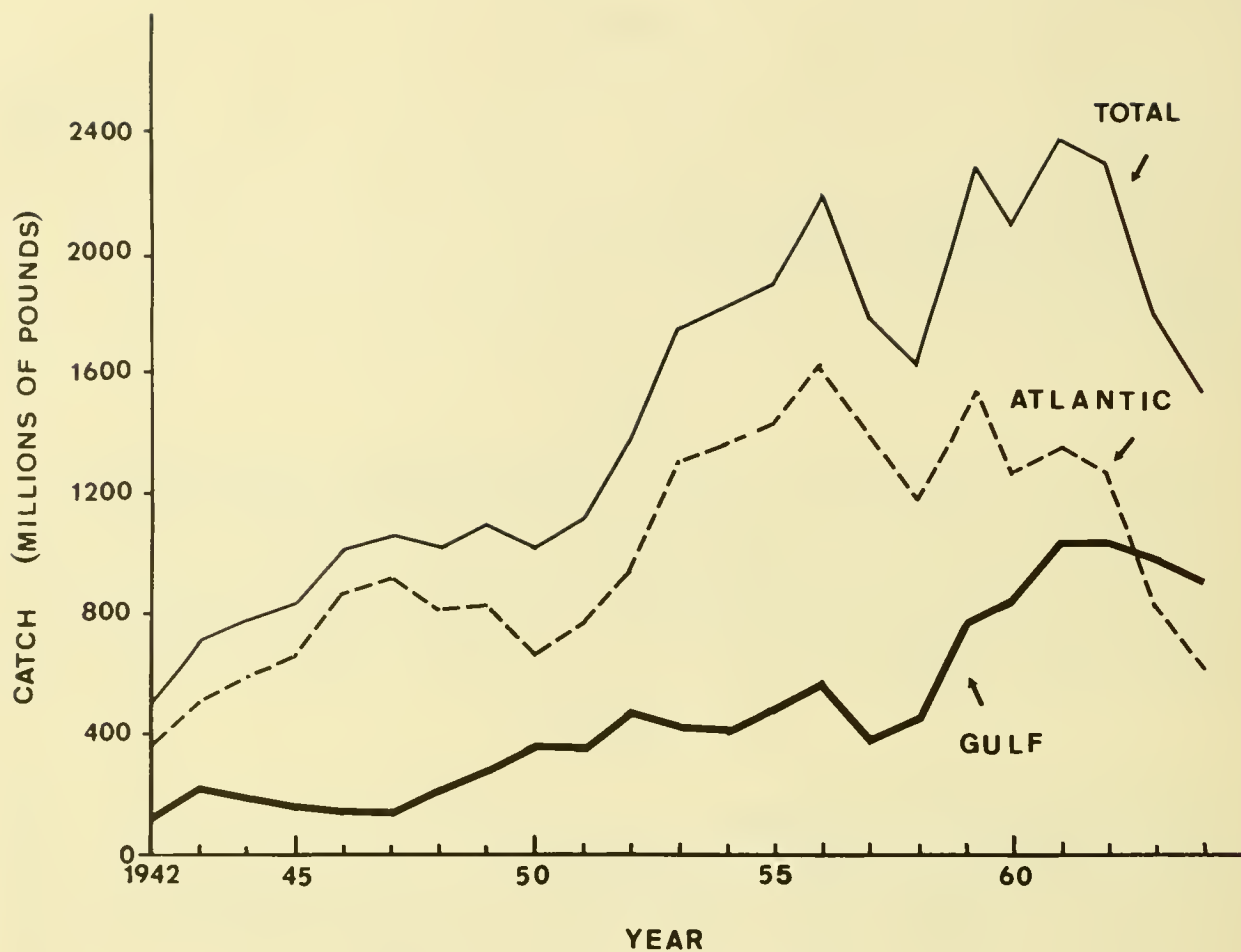


Figure 1.--Annual catch of menhaden, 1942-64.

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ABSTRACT

After record catches in 1961 and 1962 of about 2.3 billion pounds of menhaden (Brevoortia spp.), the U.S. catch declined to about 1.5 billion pounds in 1964. Most of the decrease was in the North Atlantic and Middle Atlantic areas. Since about 1940, catches have increased, in general, with increased fishing intensities. In 1963 and 1964, however, the catch per unit of effort (a standard vessel day) declined markedly. It fell from 164,000 pounds in 1962 to 110,000 in 1964 in the North Atlantic Area, and from 156,000 pounds in 1962 to 74,000 in 1964 in the Middle Atlantic Area. The increased fishing intensities and lack of older fish have caused major changes in the average age of the fish and area of catch. The strong 1958 year class, which was the main support of the fishery for several years, is no longer abundant; over 90 percent of the fish now caught are less than 3 years old. In 1964, for the first time since 1940, more menhaden were caught in the Chesapeake Bay Area than in any other area of the Atlantic fishery. Estimates of abundance of juvenile Atlantic menhaden based on trawling, haul seining, marking and recovery, and aerial observations indicate that the 1964 year class may not be as strong as that of 1963.

INTRODUCTION

More pounds of menhadens (Brevoortia spp.) than of any other species are caught annually by U.S. fishermen. After record catches in 1961 and 1962 of about 2.3 billion pounds from the combined Atlantic and Gulf coast fisheries, the catch declined to about 1.8 billion pounds in 1963 and to about 1.5 billion in 1964¹ (figure 1). Most of the decrease was in the Atlantic coast fishery, where the catch declined from 1.3 billion pounds in 1962 to 0.6 billion in 1964.

The Bureau of Commercial Fisheries began its current research on the Atlantic menhaden, B. tyrannus, in 1955. Money and personnel became available in 1964 to expand the studies to the Gulf, where a different species, B. patronus, apparently constitutes most of the catch. Since a backlog of fishery and biological data is not available for the Gulf fishery, this

report is limited principally to the Atlantic fishery.

Some of the major objectives of the menhaden investigations are to examine fluctuations in the catch, determine their cause, and, if possible, predict their occurrence. This report reviews the recent history of the Atlantic menhaden fishery and points out some of the more important current condition of the stocks.

THE FISHERY

The Atlantic menhaden fishery is principally a purse seine fishery that ranges from New England to Florida, and is divided into four geographic areas (figure 2). In addition to a summer fishery that generally extends from May to October, there is a fall fishery off North Carolina from November to January. Apparently because of migrations--in general, northward earlier in the year and southward later, at least for the older fish--the summer fishery begins somewhat later in the northern areas. Publications that describe the fishery and the biology of the species in more detail are by June (1958, 1961), Reintjes (1962), Roithmayr (1963), Sutherland (1963), Nicholson and Higham (1964), and Higham and Nicholson (1964).

Note:--Kenneth A. Henry, Director, Bureau of Commercial Fisheries, Biological Laboratory, Beaufort, N.C.

¹Gulf of Mexico landings for 1942-62 from "Fishery Statistics of the United States," a series of U.S. Fish and Wildlife Service, Statistical Digests by A. W. Anderson, C. H. Lyles, C. E. Peterson, and E. A. Power; Atlantic landings for 1940-64 and Gulf of Mexico landings for 1963 and 1964 are from menhaden reduction plant records.

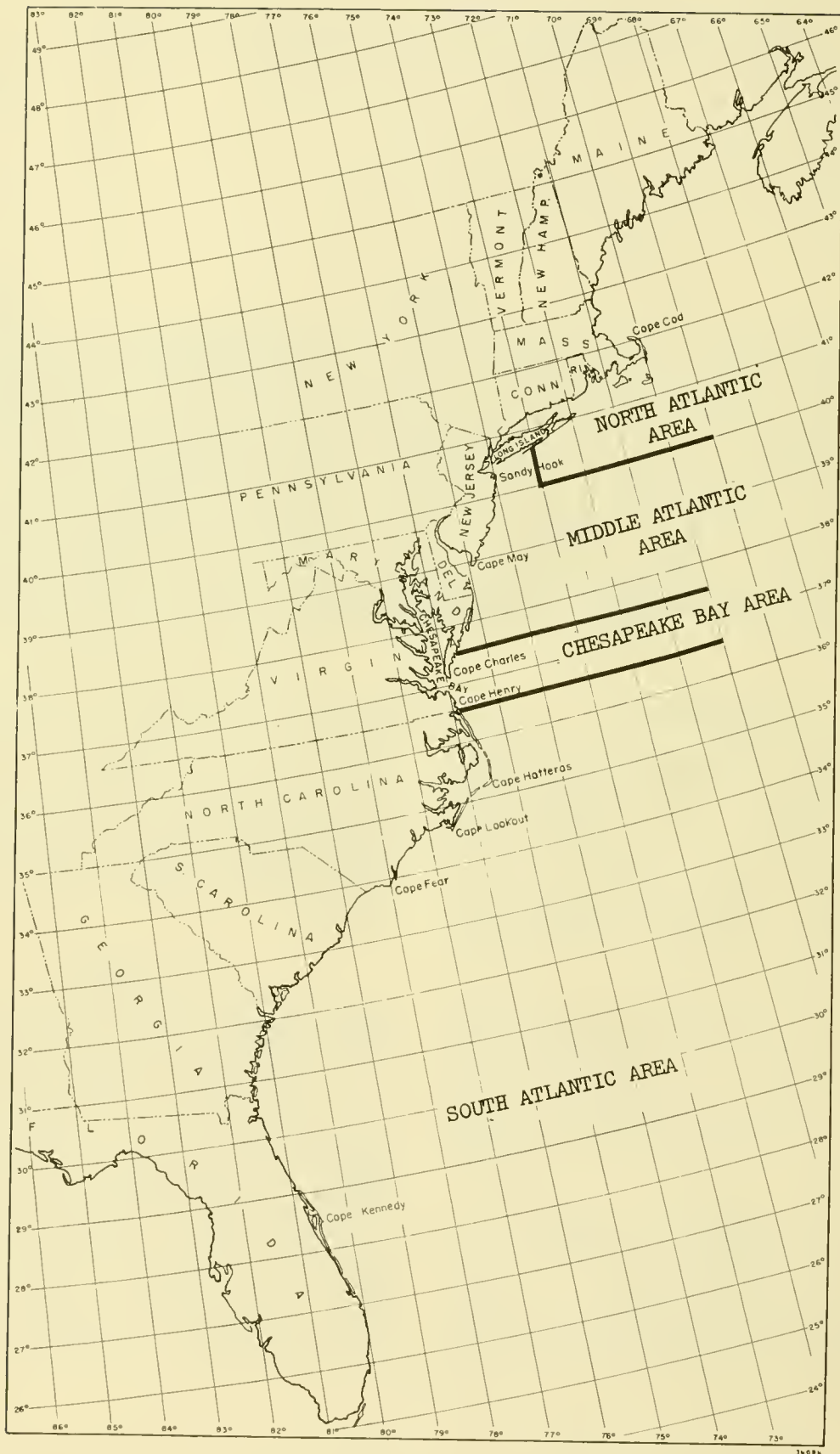


Figure 2.--Fishing areas for Atlantic menhaden.

CATCH

The annual catches of Atlantic menhaden from 1940 through 1964, by fishing area, are shown in figure 3. Catches were relatively stable in the South Atlantic Area; showed generally increasing trends in the Chesapeake Bay Area, and in the Middle Atlantic and North Atlantic Area; and (prior to 1963) were relatively stable in the North Carolina fall fishery, except for an increase in 1955 and decreases in 1962 and 1964. The decline in the catches in the Middle Atlantic and North Atlantic Areas in 1963 and 1964 is of deep concern to the fishing industry.

FISHING INTENSITY BY AREA

Fishing intensity, which also has a direct effect on the magnitude of the catch, was measured in terms of "standard vessel days"², calculated as follows: the capacity of a vessel was accepted as the average of the 10 largest loads of fish landed by it (for all years of its operation); the vessels were classified according to capacity into 6 groups, by 40-ton intervals (i.e., 141 to 180 tons, 181 to 220 tons, etc.); and the approximate midpoint of the 221 to 260-ton group (240 tons) was used as a standard vessel. The approximate midpoint capacity of each group of vessels was divided by 240 to yield a factor for the group, in terms of a standard vessel. For convenience, whole numbers--160, 200, 240, etc.--were used for approximate midpoints.) The vessel factor was multiplied by the total number of days fished by vessels of each group, and the sum of values for the groups have the total number of standard vessel days (figure 4).

The pattern of fishing intensities is similar to that of the catches shown in figure 3. In general, the increased and decreased catches accompanied increased and decreased fishing intensities prior to 1963, as is normal in a fishery.

DROP IN CATCH PER STANDARD VESSEL DAY AND TOTAL CATCH

The close relation between fishing intensity and catch changed after 1962. Although the fishing intensities in the Chesapeake Bay area have increased, the catch has not increased proportionately. Fishing intensity in this area in 1964 was about 50 percent greater than in 1962, but the mean catch per standard vessel day was only 96,000 pounds in 1964

compared to 165,000 pounds in 1962. Fishing by area intensities in both the Middle Atlantic and North Atlantic Areas decreased in 1963 and 1964, but the catches decreased faster. The mean catch per standard vessel day in the Middle Atlantic Area was only 74,000 pounds in 1964, compared with 156,000 in 1962; in the North Atlantic Area it was only 110,000 pounds in 1964 and 164,000 in 1962.

The marked declines in the production of menhaden in the Middle Atlantic and North Atlantic Areas are more apparent if only the catches since 1955 are considered (figure 5). In the Middle Atlantic Area the annual catch dropped from 862 million pounds in 1956 to only 88 million in 1964--down 90 percent. In the North Atlantic Area, the 1964 catch of 41 million pounds was down 83 percent from the 1956 catch of 236 million pounds. In the Chesapeake Bay area the 1964 catch of 296 million pounds was only average for recent years, despite increased fishing intensity. The catch of 86 million pounds in the North Carolina fall fishery was down 39 percent from 1963 (but up 48 percent from 1962). The South Atlantic Area catch in 1964 was 103 million pounds, 13 million pounds above 1963 and the largest catch in this area since 1959.

SHIFT OF FISHING EFFORT TO DIFFERENT AREAS

Another change since 1955 is the percentage of the total catch of Atlantic menhaden made in each of the fishing areas in the summer fishery (figure 6). The North Carolina fall fishery is not included in the analysis because it takes place after the fishing in the other four areas is finished. Prior to 1962 about 50 percent of the catch in the summer fishery was made in the Middle Atlantic Area, but this percentage began to decrease in 1962 and was only 17 percent in 1964. Conversely, the percentage of the catch from the Chesapeake Bay Area increased from 28 percent in 1962 to 56 percent in 1964. Thus, for the first time since 1940, more menhaden were caught in the Chesapeake Bay Area than in any other area of the Atlantic fishery. The increase in percentage of the catch from the Chesapeake Bay Area is not surprising when one considers the increased fishing intensity in 1964 compared to 1962. Chesapeake Bay was the only area with a higher fishing intensity in 1964 than in 1963.

In addition to changes in the percentage of the total catch from each area, there have been important changes in the percentage contribution of different year classes to the catches in the Chesapeake Bay and Middle Atlantic Areas. Based on scale samples collected from fish in the commercial catch, the age composition of the catch, and the catch from each year class are determined annually.

²Changes in catch and effort in the Atlantic menhaden fishery, 1940-62, by W. R. Nicholson. Unpublished manuscript, U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N.C.

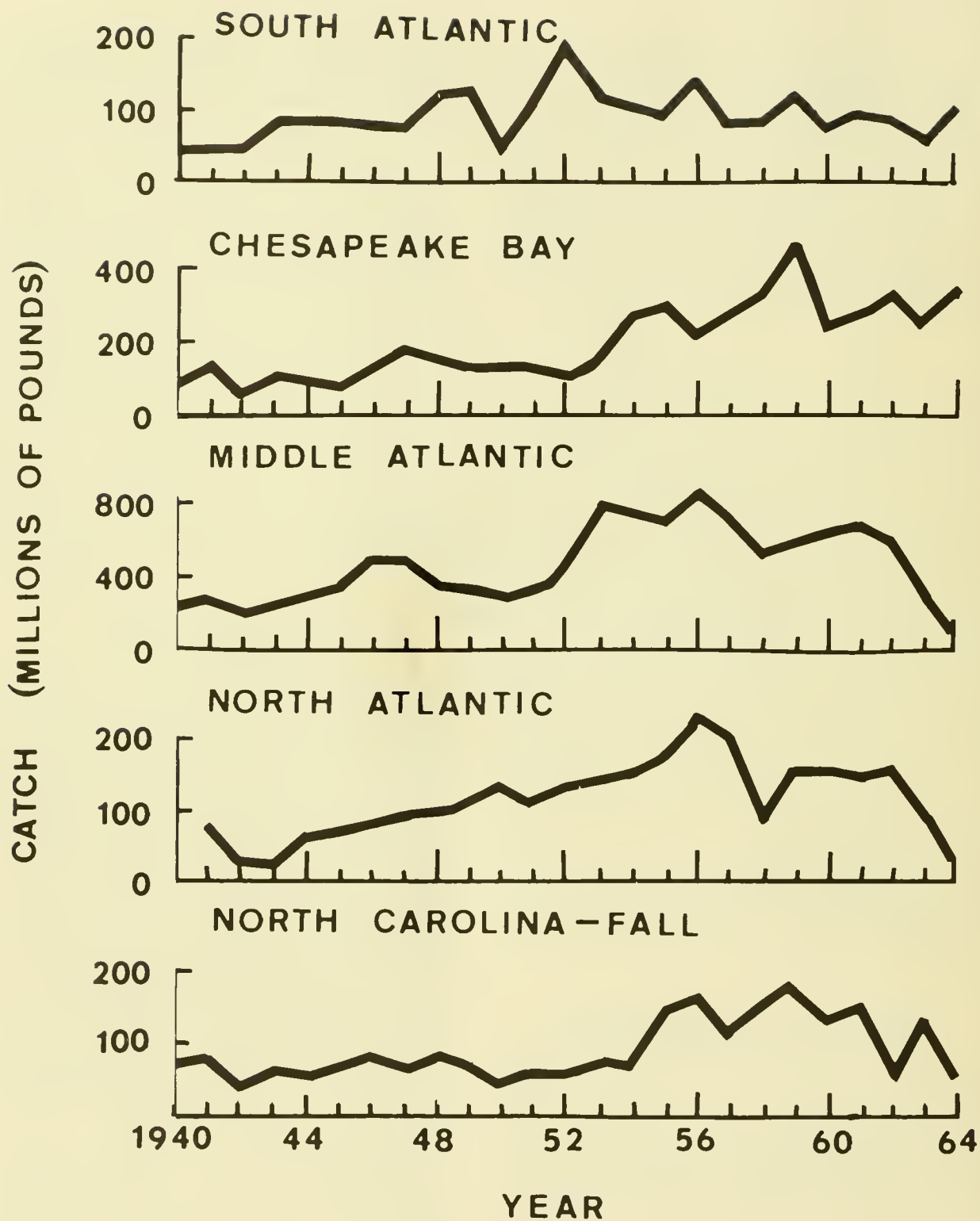


Figure 3.--Annual catch of Atlantic menhaden, by area, 1940-64.

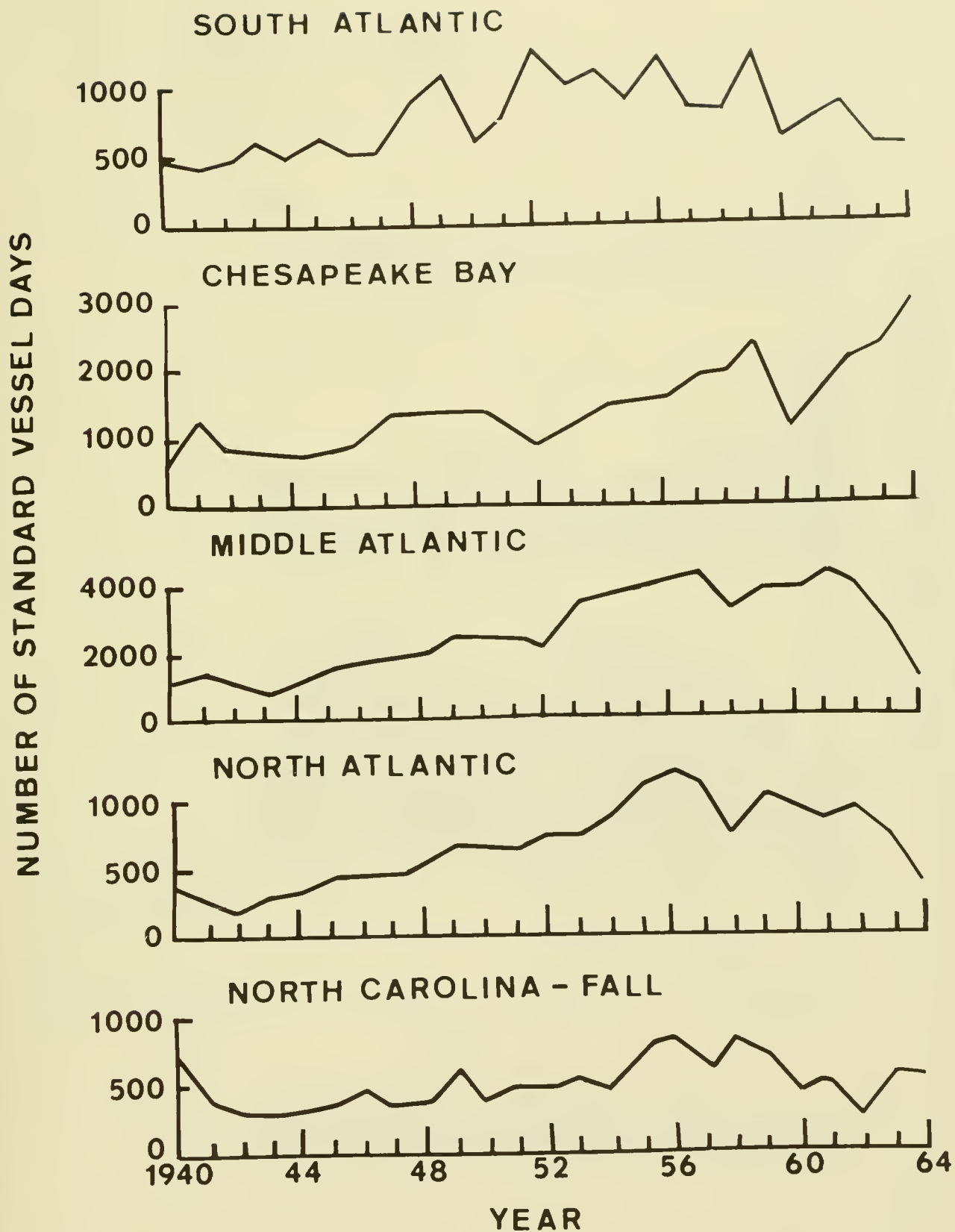


Figure 4.--Number of standard vessel days in the Atlantic menhaden fishery, by area, 1940-64.

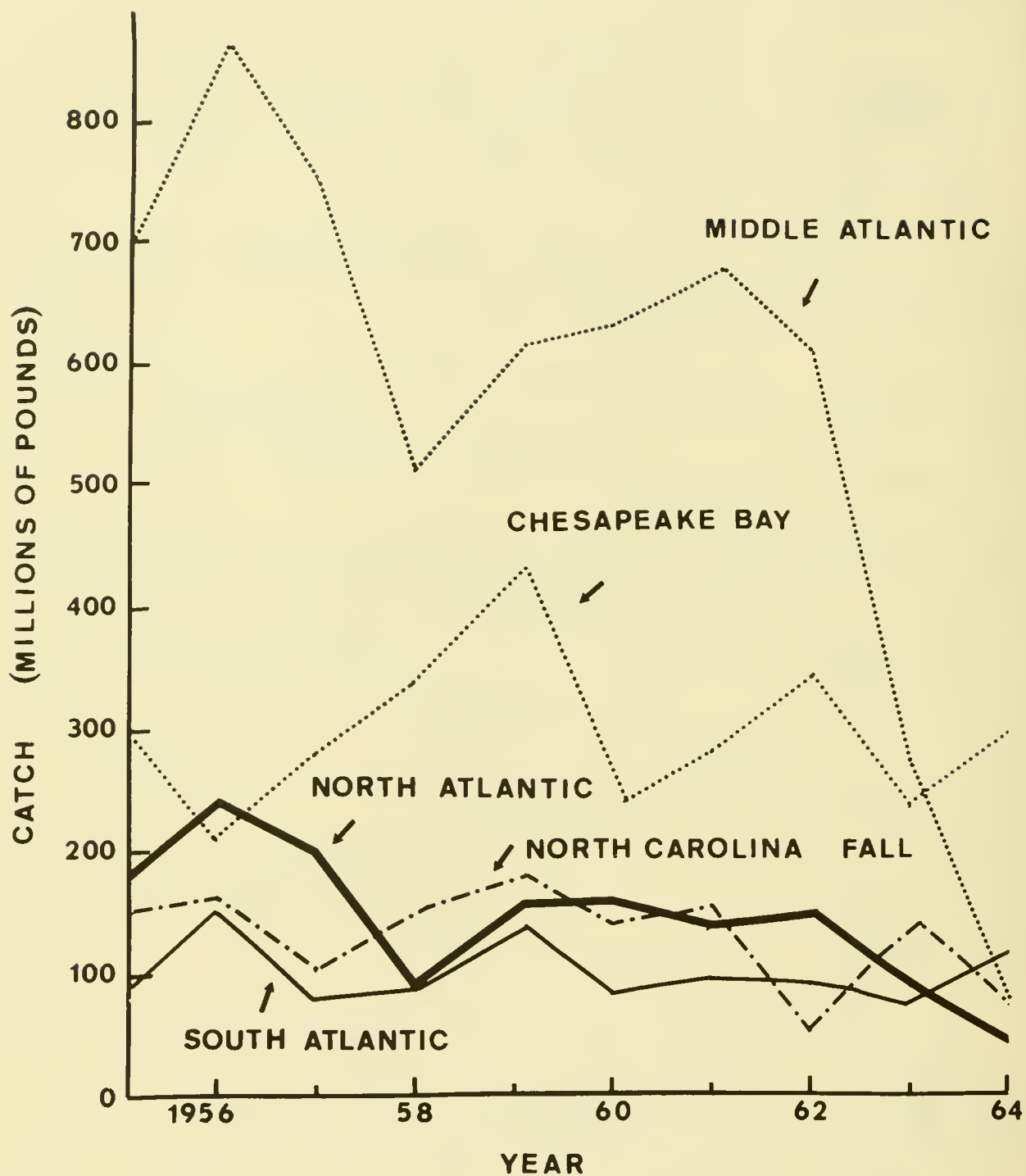


Figure 5.--Annual catch of Atlantic menhaden, by area, 1955-64.

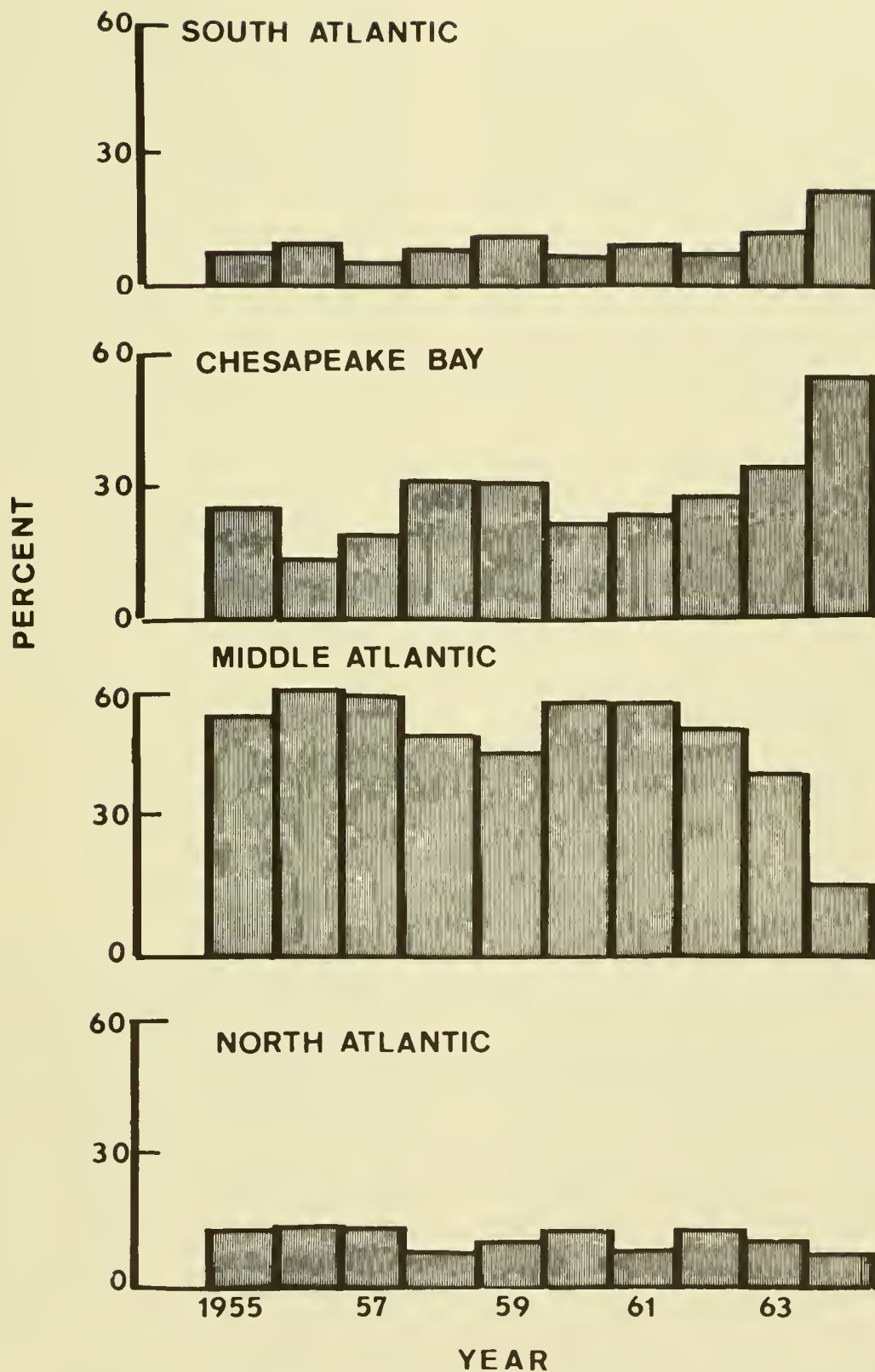


Figure 6.--Percentage of Atlantic menhaden in the summer fishery caught in different areas, 1955-64.

Of the total catch of 0-, 1-, and 2-year-old menhaden from the 1954 year class in the Chesapeake Bay and Middle Atlantic Areas, only 33 percent were caught in the Chesapeake Bay Area, and 67 percent in the Middle Atlantic Area (table 1). The percentage of fish of these ages caught in the Chesapeake Bay Area increased consistently for subsequent year classes. For two of the last three year classes on record (1960 and 1962), over 75 percent of the fish in the 0-, 1-, and 2-year-old age groups were caught in the Chesapeake Bay Area. Thus, under present fishing intensities and catches per unit of effort in these two areas, even if the 1962 and 1954 year classes had been equally abundant, the catch from the 1962 year class in the Middle Atlantic Area would have been only about one-third as large as it was from the 1954 year class.

The percentage of fish less than 3 years old in the catches from the North Atlantic, Middle Atlantic, and Chesapeake Bay Areas (data combined) has changed markedly in 1955-64 (figure 8). The catch data from the North Carolina fall fishery are not included in the figure, because the 0- and 1-year-old fish caught in this fishery probably are from a different stock of menhaden than those caught in the other four areas; likewise the relation and interchange of the menhaden stocks in the South Atlantic Area and the other areas are not understood completely. The comparatively low percentage for 1955 was due to the abundance of 4-year-old fish of the strong 1951 year class. As the 1951 year class became less abundant in succeeding years, the percentage of younger fish in the catch increased. The sudden drop in catch to less than 40 percent in 1961 was caused by

Table 1.--Estimated numbers of menhaden of different year classes caught as age-groups 0, 1, and 2 in the Chesapeake Bay and Middle Atlantic Areas, and percentage of the total number taken in each area

Year class	Catch			Percentage of total catch	
	Chesapeake Bay	Middle Atlantic	Total	Chesapeake Bay	Middle Atlantic
	<u>Millions of fish</u>				
1954.....	410	840	1,250	33	67
1955.....	863	1,123	1,986	43	57
1956.....	1,618	1,153	2,771	58	42
1957.....	694	542	1,236	56	44
1958.....	2,726	2,272	4,998	55	45
1959.....	360	201	561	64	36
1960.....	678	218	896	76	24
1961.....	391	237	628	62	38
1962 ¹	750	225	975	77	23

¹Preliminary.

AVERAGE AGE OF CATCH

The annual average age of Atlantic menhaden in the catches varies among areas (figure 7). From 1955 through 1964, the annual average age in the catch in the North Atlantic Area varied between 2.9 and 4.5 years; in the Middle Atlantic Area, between 1.6 and 3.2 years; in the South Atlantic Area between 1.0 and 1.7; and in the Chesapeake Bay Area, between 1.1 and 1.8 years. The average age in the North Carolina fall fishery, although fluctuating between 0.3 and 3.0 years, has increased. The increased average age in several areas in 1960, 1961, and 1962 was caused by the dominance of the 1958 year class. By the time the menhaden from the 1958 year class were 5 and 6 years old in 1963 and 1964, the decrease in abundance of this year class was reflected by the decreased average age of fish in the catch.

the large catch of 3-year-old fish from the dominant 1958 year class. The very large 1958 year class was the main support of the North Atlantic Area in 1960-63 and the Middle Atlantic Area in 1959-62, but these fish no longer are present in sizeable numbers. Since 1961, as the fish from the 1958 year class have become older and less abundant, the percentage of younger fish in the catch has increased. Except when older fish from an exceptionally strong year class were in the fishery, the catch in the North Atlantic, Middle Atlantic, and Chesapeake Bay Areas in 1955-64 has been composed principally of menhaden less than 3 years old. The older fish, which helped to stabilize violent fluctuations in the catch resulting from variation in the strength of year classes, no longer are present in significant numbers. The present fishery, which relies principally on young fish, will be much more sensitive to fluctuations in year-class strength.

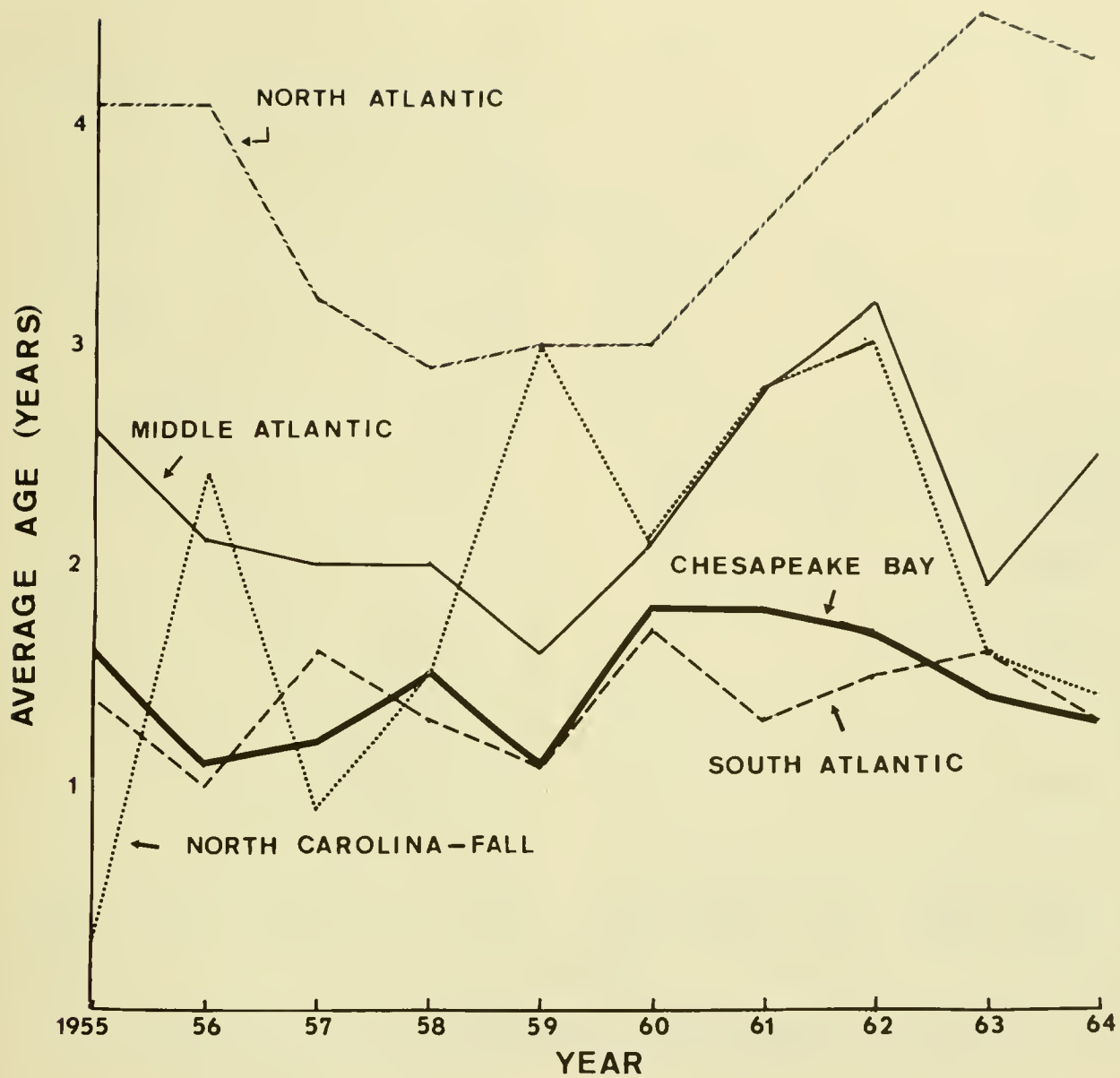


Figure 7.--Average age of Atlantic menhaden in the catch, by area, 1955-64.

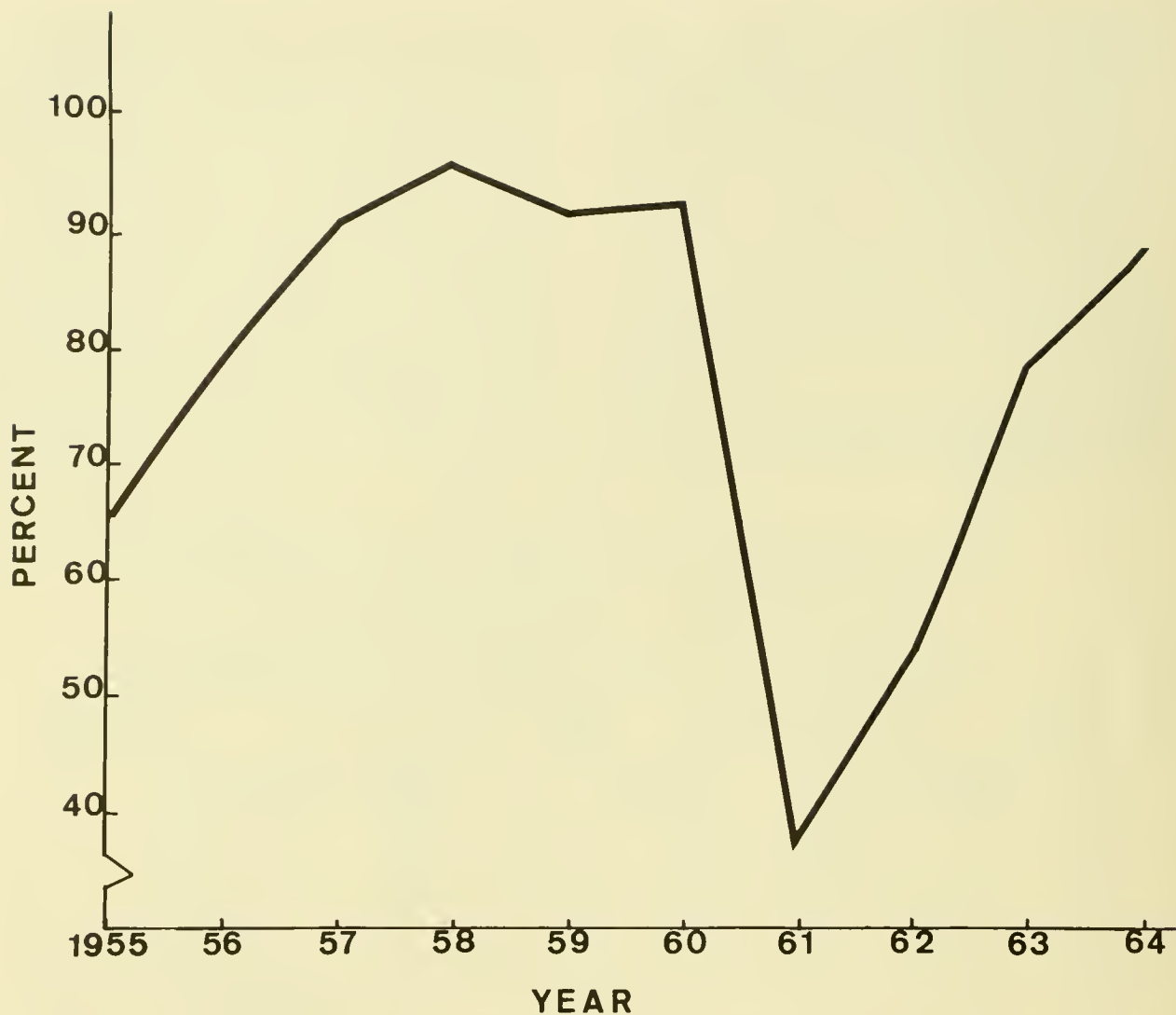


Figure 8.--Percentage of the total annual catch of Atlantic menhaden which were 0, 1, and 2 years old, from the North Atlantic, Middle Atlantic, and Chesapeake Bay Areas combined, 1955-64.

ESTIMATES OF ABUNDANCE

The most recent strong year class of Atlantic menhaden was that of 1958. In the absence of a strong year class, the catch will consist mainly of menhaden less than 3 years old. Even with the appearance of a strong year class, the catch would consist mainly of menhaden less than 3 years old for at least 2 additional years. Since age-0 menhaden have always been relatively unimportant in the catch, it will be the age-1 and -2 fish, or the 1963 and 1964 year classes, which will make up the bulk of the catch in 1965. The 1963 year class of menhaden, caught as age-1 fish in 1964, was not particularly strong. The catch of age-1 fish was less than in 1964 in only 2 years since 1955 in the South Atlantic Area and in only 1 year since 1955 in the Chesapeake Bay Area (even though fishing intensity was the highest on record in the Chesapeake Bay Area in 1964).

A project has been started to estimate the relative abundance of 0-group, or juvenile menhaden, in various Atlantic coast estuaries 1 year before they enter the fishery. Several estimates are made each year based on (1) trawling, (2) haul seining, (3) marking and recovery of juveniles, and (4) counting schools of juveniles from an airplane. Estimates were made by haul seining and marking for the 1961 year class and by all methods for the 1962, 1963, and 1964 year classes. Because the data have been compiled for only a few years, we have not been able to assess fully the reliability of the estimates for predicting the contribution of each year class to the fishery.

Trawling, the first method used each year, usually is begun in June and repeated in some estuaries in July and August.³ The trawl, similar to one described by Massmann, Ladd, and McCutcheon (1952), has an opening about 24 feet wide by 3½ feet high. The net is towed between two outboard motor boats; three to six tows of 5 minutes each are made in an estuary during each survey. For most estuaries, the mean number of juvenile menhaden caught per tow was lower in 1964 than in 1963 (table 2).

Estimates by haul seining, and by marking and recovery are made during July and August. About 30 to 40 hauls are made in each location, over a 4-day period. The mean catch per seine haul and the population estimate based on marking and recovery of juveniles appear to vary in a similar manner; therefore, the estimates based on marking are not presented here. The reduction in the catch in 1964 was more pronounced in haul seines (table 3) than it was in trawls (table 2).

³Observations of juvenile Atlantic menhaden based on surface trawl catches in Bath Creek, N.C., by A. L. Pacheco. Unpublished manuscript, U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N.C.

Table 2.--Average number of juvenile menhaden caught per 5-minute trawl tow in selected Atlantic coast estuaries in June, 1963 and 1964

Estuary	1963	1964
	Number	Number
Sawmill, S.C.	1,485	581
Meggetts, S.C.	769	804
Calabash, N.C.	1,827	1,392
Broad, N.C.	3,776	32
Bath, N.C.	1,946	3,828
Felgate, Va.	3,728	926
Ball, Va.	721	9
Colbourn, Md.	43	37
White, Del.	172	385

Table 3.--Average number of juvenile menhaden caught per seine haul in selected Atlantic coast estuaries, July and August, 1963 and 1964

Estuary	1963	1964
	Number	Number
Sawmill, S.C.	436	68
Calabash, N.C.	233	19
Broad, N.C.	1,429	81
Felgate, Va.	408	119
Ball, Va.	759	3
White, Del.	1,067	153

Estimates of abundance also are made each fall by counting schools of juvenile menhaden from an airplane. Briefly, the observer estimates the area, in square feet, of each menhaden school sighted along a prescribed flight path. The total square feet divided by the miles of flight gives an estimated number of square feet of juvenile menhaden per mile. Data for 1963 and 1964 are shown in table 4. Some areas have more than one estimate shown each year, for observations made on different dates. A decrease in the area of menhaden schools in 1964 is apparent.

In the 10 years since the start of the Atlantic menhaden investigations, significant contributions have been made to the biological knowledge of this species and to an understanding of the relations between the fishery and the stocks. However, the current increased fishing intensity on young fish, decreased catches, and shift in the area of greatest catch have raised certain important questions, such as: (1) Is there overfishing, (2) what are the interrelations of the stocks in the different areas, and (3) what are the effects of water temperature, salinity, and water currents during spawning on survival of a year class? These questions cannot be answered completely without increased research.

Table 4.--Areas of schools of juvenile Atlantic menhaden seen per mile of flight based on aerial observations, 1963 and 1964

Area	1963	1964	Ratio of 1964/1963
	<u>Sq. ft. per mile</u>	<u>Sq. ft. per mile</u>	<u>Percent</u>
Long Island Sound.....	313	4	1.3
Do.....	250	222	88.8
Severn River, to Patuxent River, Md.	259	285	110.0
Do.....	111	41	36.9
Patuxent River, Md.	91	42	46.2
Do.....	38	14	36.8
Potomac River, Md.	448	55	12.3
Do.....	132	0	--
Rappahannock River, Va.	55	7	12.7
York River, Va.	24	6	25.0
James River, Va.	75	26	34.7
Albermarle Sound, N.C.	175	15	8.6
Do.....	891	15	1.7
Pamlico Sound, N.C.	40	206	515.0
Do.....	43	0	--
Charleston Harbor, S.C.	222	4	1.8
Do.....	26	4	15.4
Savannah River, Ga.	15	0	0

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